Microwave Investigation of the Mars Atmosphere and Surface

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ABSTRACT

Scientific Goals and Objectives

The Microwave Investigation of the Mars Atmosphere and Surface Experiment (MIMAS) is designed to address two major scientific goals:

1) To understand the three dimensional general circulation of the Martian atmosphere, and

2) To understand the hydrologic cycle of water on Mars, including the time-variable sources, sinks, and atmospheric transport of water vapor.

The proposed instrument is a submillimeter wave, heterodyne receiver, with both continuum and very high spectral resolution capability. A small reflector antenna will be used to feed the receiver. Instrument heritage comes from the MIRO receiver, currently under design for the ESA Rosetta Mission, and from SWAS, a NASA astrophysics mission. The instrument will be able to measure atmospheric spectral lines from both water and carbon monoxide and use these lines as tracers of atmospheric winds.

Measurement objectives of MIMAS are to measure surface temperature, atmospheric temperature from the surface up to an altitude of 60 km or more, the distribution of CO and H_2O in the atmosphere, and certain wind fields (zonal and meridional). The global distribution of CO, as well as temperature distributions, will be used as input data for GCMs (general circulation models). Water vapor profiles will be used to understand the sources and sinks of water on Mars and to understand how it is transported globally by the general circulation. Zonal and meridional wind fields will provide further tests of the GCMs.

An important aspect of this experiment is that the temperature and humidity measurements are insensitive to dust and ice condensates thereby making the measurement capability independent of the presence of dust clouds and ice particles. Temperature measurements derived from the data can be used in conjunction with infrared measurements to determine dust profiles.

Relationship of MIMAS Investigation to Mars Scientific Goals

To achieve Mars science objectives	MIMAS will	Corresponding MIMAS objectives
Global atmospheric circulation and high-resolution mapping of atmospheric composition	• Perform three dimensional mapping of time variable atmospheric state parameters: temperature, winds • Perform three dimensional mapping of water vapor and carbon monoxide	Improve the phenomenological description of the present three-dimensional general circulation and develop a quantitative description of the processes controlling the circulation.
Surface-atmosphere interactions	• Perform global mapping of atmospheric water vapor • Perform global mapping of subsurface brightness temperature	Develop a quantitative understanding of the time-variable sources, sinks, and atmospheric transport of water vapor.

Proposed Instrument

MIMAS is a remote sensing, surface and atmospheric investigation of Mars, based on the use of submillimeter wave instrumentation, and responsive to key objectives of the NASA Mission to the Solar System. The MIMAS instrument will remotely measure temperature, water vapor and CO profiles in the atmosphere from ground level up to 80 km or more, and near surface temperatures to a depth of approximately 1 cm. The instrument would be flown on a Mars Micromissions orbiter and would be capable of both nadir sounding and limb sounding. Temperature sounding is achieved by measuring the thermal emission line shape of rotational transitions of the J=5-4 rotational transitions of $C^{13}O$ and $C^{12}O$ near 0.52 mm wavelength (551 and 576 GHz). Water vapor measurements are achieved by measuring the ground state rotational transition of $H_2{}^{18}O$ and $H_2{}^{16}O$ (548 and 557 GHz). The vertical distribution of CO would also be retrieved from the two observed CO transitions in addition to temperature. The MIMAS

instrument relies heavily on hardware currently under development for the MIRO science instrument on ROSETTA.

The MIMAS instrument utilizes a hetrodyne down-converter to receive thermal atmospheric radiation in a frequency band near 557 GHz. This submillimeter down-converter is almost identical to that used on the MIRO instrument. The input signal is directed to the receiver by a telescope, with 70-mm diameter aperture (0.5-degree beam) (or 140 mm for a Mars geostationary orbit), capable of being directed toward the atmosphere and surface of Mars or toward calibration sources. The sources consist of a view of cold space and an ambient temperature calibration target to enable absolute brightness temperature accuracy of the order of 1K. The input signal is down-converted to an intermediate microwave frequency (IF) and processed through further down- and up-converters which fold the four line input spectrum into a narrow band near 1,350 MHz. Part of this signal is applied to a wide band filter, detected, integrated and digitized to provide a measure of the continuum background radiation. Another part is the applied to a Chirp Transform Spectrometer (CTS) which filters the spectrum into 4,096 channels with 50 kHz resolution. The signal from these bands are then detected, integrated and digitized to produce measurements of the spectral line intensities and shapes. Additional supporting subsystems are a frequency synthesizer to provide stable signals for the down-conversion processes, telescope pointing control, computer and data processing, power conditioning and mechanical and thermal control. Key instrument performance characteristics are given in the following table:

Frequency	548-576 GHz	Wavelength	0.54 mm
DSB System Temperature	5,000 K	Telescope Diameter	70 - 140 mm
Beamwidth (HPFW)	0.25-0.5 degree	Nadir Spatial Resolution	5 ñ 100 km
Spectral Resolution	50 kHz	Spectrometer Bandwidth	200 MHz
Continuum Bandwidth	500 MHz	Continuum Sensitivity (rms)	1 K (1 s)

SUMMARY OF REQUIRED SPACECRAFT RESOURCES

Mass:	9.7 kg
Volume:	<20 dm^3
Size:	290 x 240 x 330mm
Power Supply: Continuum Mode	20 W
Full Mode	53.1 W

IMPLEMENTATION APPROACH

It anticipated that the MIMAS instrument would be developed as a collaboration of JPL/NASA, Germany, France and the UK.